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Ohio M-R 13: A New Greenhouse Tomato Variety Resistant to Five Ohio Strains of TMV

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LEONARD J. ALEXANDER and JAMES D. FARLEY[1]

SUMMARY

A new pink-fruited greenhouse tomato variety, Ohio M-R 13, is described. This new variety is resistant to the five Ohio strains of the tobacco mosaic virus (TMV). Because it is resistant to TMV, the severely destructive diseases *combination streak* and combination TMV-cucumber mosaic virus (CMV) are also eliminated. Preliminary evidence also indicates that the variety is resistant to *glasshouse streak*. This new variety is partially susceptible to the physiological disease *blotchy ripening*.

The vine and fruit characteristics of Ohio M-R 13 are of the Livingston Globe type. Its yielding ability appears to equal or exceed Ohio M-R 12. Its fruit qualities appear superior and thus returns to the grower should be greater. Other aspects of the variety are described in detail.

INTRODUCTION

In 1970, Alexander and Oakes (2) introduced two TMV-resistant greenhouse tomato varieties. Since then, one of these varieties, Ohio M-R 12, has become the main variety grown in Ohio greenhouses. A third breeding line given to greenhouse growers was received without enthusiasm at first but has since become highly regarded. This paper describes the third new pink-fruited TMV-resistant greenhouse tomato variety, Ohio M-R 13.

The history of the development of varieties resistant to TMV was reported in detail by Alexander and Oakes (2) and is not repeated here.

PARENTS AND PEDIGREE OF NEW VARIETY

The parents and methods of breeding were previously described by Alexander and Oakes (2). The pedigree of Ohio M-R 13 is illustrated in Figure 1. It differs from that of Ohio M-R 12 in that the last cross was made to Ohio W-R 25 instead of Ohio W-R 29.

GENERAL CHARACTERISTICS OF OHIO M-R 13

This new variety is of the Livingston Globe type and closely resembles the older Ohio W-R 25, Ohio W-R 29, and the relatively new Ohio M-R 12 varieties.

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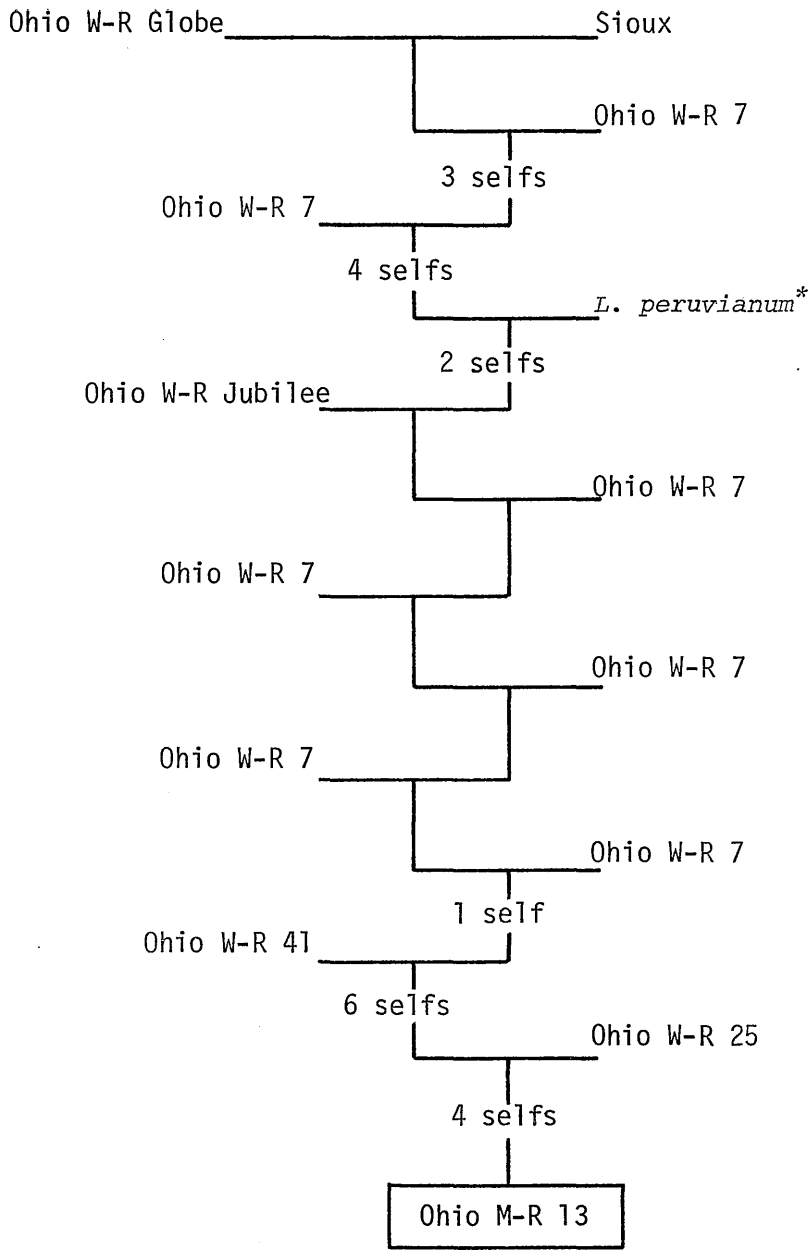

Lycopersicon peruvianum (P.I. 128650-6Y-IV-1-12-22)

FIG. 1.—Pedigree of Ohio M-R 13. Note that nine backcrosses or outcrosses were made to good type.

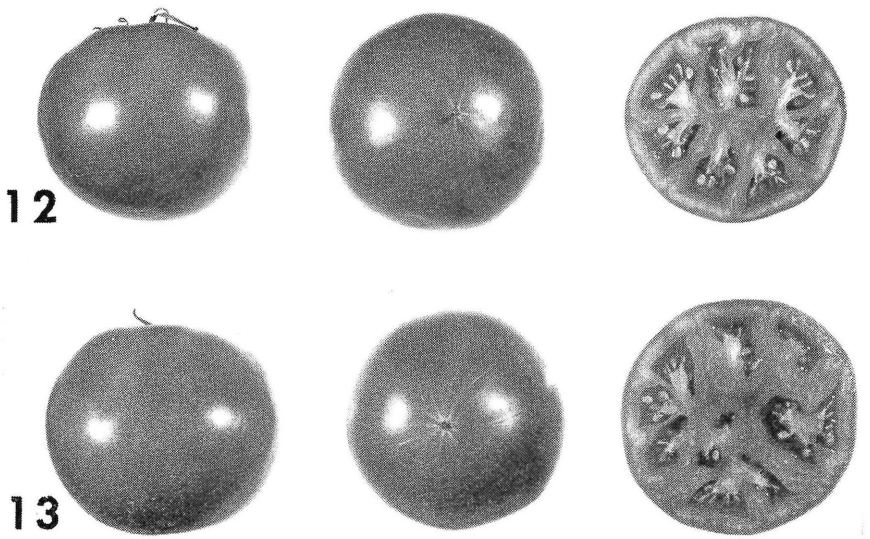

FIG. 2.—Views of whole and transverse sections of Ohio M-R 12 and Ohio M-R 13.

Fruit Shape: Fruit shape of Ohio M-R 13 under normal growing conditions is globose (Figure 2). In comparison with Ohio M-R 12, the fruit is more nearly globose, but under some conditions may be slightly ovate or slightly oblate.

Internal and External Fruit Color: Ohio M-R 13 has the gene *u* for uniform ripening, and thus tends to have a light whitish green color when unripe. The whitish green color in fruits of Ohio M-R 12 and Ohio M-R 13 is a darker shade of green than Ohio W-R 25, even though all three varieties have the gene for uniform ripening.

The first indication of maturing fruits of Ohio M-R 13 is the development of a pinkish color. As the fruits reach full maturity, they develop a crimson red color. In some cases just before deterioration starts, the fruit develops a slight purplish red. Originally, colorless skinned tomatoes were generally referred to in the trade as purples.

The internal color of the fruits is light red. There is a minimum of whitish vascular tissue (Figure 2).

Firmness: During the development of Ohio M-R 13, vigorous efforts were made to select fruits for firmness and thick carpel walls. As a result, the fruits of Ohio M-R 13 equal or exceed the quality of any of the earlier Livingston Globe types. This firm character should give Ohio M-R 13 good shipping qualities.

FIG. 3.—Ohio M-R 13 plant growing in a commercial greenhouse

Smoothness: Fruits of Ohio M-R 13 are slightly smoother than those of Ohio M-R 12 and probably equal to those of Ohio W-R 25. There is also less tendency to produce occasional large, rough fruit on early clusters.

Plant Vigor: Observation of plants of Ohio M-R 13 indicated that they were of equal vigor with Ohio M-R 12 and that both were more vigorous than Ohio W-R 25. Because of TMV resistance, plants of Ohio M-R 13 tend to maintain their vigor throughout the season and avoid the loss of two clusters which commonly occurs in TMV-infected plants.

Temperature and Water Requirements: The temperature and water requirements for Ohio M-R 13 are similar to those of Ohio M-R 12.

It should be emphasized that plants of every tomato variety grow and produce best when grown under a regime best suited for them. This is usually a matter of adjusting the temperature (both day and night), irrigation procedures, and fertilization practices to obtain the best economic returns.

Fruit Setting Potential: The only significant difference in fruit setting between Ohio M-R 12 and Ohio M-R 13 is that the latter tends to set slightly less. An Ohio M-R 13 plant with good fruit set is illustrated in Figure 3.

Maturity: The maturity of Ohio M-R 13 is not significantly different from that of Ohio M-R 12. However, both varieties appear to be 2 to 5 days later than Ohio W-R 25. The difference in maturity can be overcome to some extent by planting a few days earlier.

RESISTANCE TO OTHER DISEASES

In the development of Ohio M-R 13, there were six backcrosses to Ohio W-R 7, one outcross to Ohio W-R 25, and two outcrosses to greenhouse breeding lines. Therefore the new variety would be similar to older greenhouse varieties except for the addition of the Tm-2^a gene for resistance to the five known Ohio strains of TMV. Although it has been shown by Alexander and Cirulli (1), Cirulli and Alexander (3), and Schroeder *et al.* (4) that TMV necrosis can occur in plants homozygous for the gene Tm-2^a, necrosis has not occurred in large-scale commercial plantings of TMV-resistant varieties.

Plants possessing the gene Tm-2^a are susceptible to the cucumber mosaic virus (CMV) and potato virus X (PVX). When plants are artificially inoculated with TMV and then either virus CMV or PVX, only symptoms of the latter two viruses are seen singly (Table 1). Thus, by growing TMV-resistant plants, the severe diseases combination streak (TMV + PVX) and combination CMV (TMV + CMV) are eliminated (Table 1). The effects of combination streak are shown in Figure

4. Losses caused by infection of plants with either of the viruses CMV or PVX alone will still be sustained.

The new tomato variety Ohio M-R 13 is partially resistant to the blotchy ripening fruit disease but does not have the high resistance of the varieties Ohio W-R 25 and Ohio W-R 29. However, commercial growers who have grown the TMV-resistant varieties have experienced very little or no losses from the disease. The new variety is resistant to race I of the Fusarium wilt pathogen, *Fusarium oxysporium* f. *lycopersici;* to fruit cracking; and to fruit pox. It is tolerant to high manganese soil content and the fruits are relatively free of white vascular tissue.

TABLE 1.—Symptoms Produced by TMV, CMV, PVX, and the Combinations TMV + CMV and TMV + PVX on TMV-Resistant and Susceptible Plants.* † ‡

Variety	First Virus Inoculation 11/29/71	Plant Symptoms 12/10/71	Second Virus Inoculation 12/10/71	Plant Symptoms 1/18/72
		TMV		
Ohio M-R 12	TMV	Healthy	—	Healthy
Ohio W-R 25	TMV	Mottled	—	Mottled
		CMV alone and TMV + CMV		
Ohio M-R 12	None	Healthy	CMV	Some plants mottled
Ohio W-R 25	None	Healthy	CMV	Some plants mottled
Ohio M-R 12	TMV	Healthy	CMV	Slight stunting and mottle
Ohio W-R 25	TMV	Mottled	CMV	Slight stunting and mottle and some plants with filiforme leaves
		PVX alone and TMV + PVX		
Ohio M-R 12	None	Healthy	PVX	Mottled and very slight stunting
Ohio W-R 25	None	Healthy	PVX	Mottled, slight stunting and yellowing
Ohio M-R-12	TMV	Healthy	PVX	Mottled
Ohio W-R 25	TMV	Mottled	PVX	Mottled, stunted, severe yellowing, leaf necrosis and stem streaking

*Ten plants were used in all tests. Tests were conducted in a greenhouse thermostatically controlled at 80° F. Supplementary light was used to give a 16-hour day.

†TMV=Tobacco mosaic virus strain 5. CMV=Cucumber mosaic virus. PVX=Potato mosaic virus.

‡All uninoculated control plants remained healthy.

FIG. 4.—Plant showing effects of infection with TMV plus PVX combination streak (left) and healthy plant (right).

COMPARATIVE YIELD DATA

OARDC Yield Data: Yield and fruit size from the Ohio Agricultural Research and Development Center greenhouses are given in Tables 2 and 3.

Variety testing and evaluation in greenhouses is extremely difficult because the researcher who regulates the temperature, irrigation water, and composition of fertilizer is always faced with the question, what regime shall I follow? If the decision is made to favor the older accepted variety, then new and better varieties may be handicapped and be discarded. On the other hand, if growing conditions had been maintained for the best growth and production of a specific new variety, then this variety might have excelled from the first.

Commercial growers testing new varieties are also faced with the same dilemma. They may have only a row or two of a new variety and therefore must grow the new variety under the regime which favors the main planting. If a large number of growers grow a new trial strain and it receives some good reports, it probably has promise. It is then necessary for growers to grow it in large blocks under favorable conditions and determine the real yield and grade potential.

TABLE 2.—Comparative Yields of Ohio M-R 13 and Two Commercial Varieties.*

	Spring Crops				Fall Crops	
Varieties	**1968**	**1969**	**1970**	**1971**	**1968**	**1970**
	8-Lb. Baskets per Acre					
Ohio M-R 13	18,740	11,338†	16,165	15,924	9,269†	8,518
Ohio M-R 12	17,530	10,947	16,177	13,467	10,258†	8,482
Ohio W-R 25	15,090	13,535	16,419	18,937	9,210	9,583

*OARDC Plant Pathology greenhouses.
†Replicated plots. All others were single row plots.

TABLE 3.—Comparative Fruit Weight in Ounces of Ohio M-R 13 and Two Commercial Varieties.*

	Spring Crops				Fall Crops	
Varieties	**1968**	**1969**	**1970**	**1971**	**1968**	**1970**
Ohio M-R 13	5.3	4.8†	4.9	4.9	3.9†	4.3
Ohio M-R 12	5.4	4.2	5.0	4.5	3.8†	4.2
Ohio W-R 25	4.8	4.7	5.1	6.0	3.8	4.1

*OARDC Plant Pathology greenhouses.
†Replicated plots. All others were single row plots.

The data in Table 2 indicate that the yields from Ohio M-R 13 equal those of other varieties. Since most of the data in Table 2 are from single row plots, it is not surprising that there is considerable variation in ranking among the varieties. The comparative fruit size of Ohio M-R 13, measured by weight in ounces, is shown in Table 3. It should be noted that there is a tendency for the fruits of Ohio M-R 13 to be larger than Ohio M-R 12. This observation appears to be substantiated by commercial growers.

Yield Data from Commercial Greenhouses: Through the courtesy of several greenhouse tomato growers, comparative yield and grade data were obtained on Ohio M-R 13 and commercial varieties. These data are presented in Tables 4, 5, and 6.

The yield data in Table 4 were secured from six greenhouse growers. It is probably representative of the performance of the varieties under commercial conditions, with the exception that Ohio M-R 13 was grown under the regime best suited for the variety used in the main plantings. It should be noted that Ohio M-R 13 and Ohio M-R 12 produced as well as the control varieties. There was little consistency as to which variety performed best, presumably due to the variation in growing regimes.

TABLE 4.—Comparative Yields of Ohio M-R 13 in Commercial Greenhouses, Spring Crop, 1969.

Grower	Ohio M-R 13	Ohio M-R 12	Controls
		Pounds per Plant	
A	11.7	13.9	13.3 (H.O.)
B	12.2	11.4	10.2 (Ohio W-R 7)
C	10.7	12.3	11.9 (Ohio W-R 25)
D	11.7	14.1	11.5 (Ohio W-R 25)
E	15.6	16.9	17.5 (Ohio W-R 25)
F	19.3	20.5	22.6 (Ohio W-R 25)

TABLE 5.—Comparative Yields of Ohio W-R 13 and Two Commercial Varieties.*

	8-Lb. Baskets per Acre						
	Spring Crops				Fall Crops		
Varieties	1969	1970	1971	1972	1969	1970	1971
Ohio M-R 13	14,764	—	17,554	26,956	6,278	8,254	8,370
Ohio M-R 12	15,926	23,017	18,368	27,787	6,278	9,187	7,556
Ohio W-R 25	17,438	20,460	19,646	—	6,162	7,091	—

*Data furnished by courtesy of a commercial grower.

TABLE 6.—Comparative Percentage Grading Data by Weight for Ohio M-R 13 and Two Commercial Varieties. Average of Either 2 or 3 years.*

Variety	Grade				
	Select	Large	Select Small	B-grade	Off-grade
	Spring Crops				
Ohio M-R 13	71.1	8.0	9.8	8.0	3.2
Ohio M-R 12	69.4	5.5	14.0	7.7	1.8
Ohio W-R 25	70.3	8.5	11.2	7.4	2.6
	Fall Crops				
Ohio M-R 13	62.0	5.2	15.6	14.2	2.9
Ohio M-R 12	64.3	8.0	15.1	14.6	2.2
Ohio W-R 25	60.8	3.5	19.8	12.0	4.2

*Data supplied by courtesy of a commercial grower.

The yield and grading data in Tables 5 and 6 were secured from a single greenhouse grower who maintains variety test plots. Data are from four spring and three fall crops. It should be noted in Table 5 that the total production of the three varieties varied considerably from year to year. If these tests had been replicated, there probably would have been more consistency in results.

Grading data are in Table 6. The *select* grade comprises the bulk of the crop and the price received for it determines the price received for fruit in the other grades. Thus, it is important that all varieties produce a high percentage of *select* fruit. The data in Table 6 show that the new TMV-resistant varieties equal or exceed Ohio W-R 25 in this respect. This is an important consideration because Ohio W-R 25 was the best greenhouse variety until the development of the TMV-resistant lines.

DISCUSSION

Introduction of Ohio M-R 13 brings the ideal TMV-resistant greenhouse variety a step closer but does not end the necessity for continuing the TMV resistance breeding program. Efforts are underway to combine the high blotchy ripening resistance of Ohio W-R 25 with TMV resistance. Where this has been accomplished thus far, the fruit of such plants tends to be too rough for commercial use. Continued work is needed to improve these breeding lines.

Yield data presented here on the performance of Ohio M-R 13 are not extensive. However, a large number of commercial greenhouse growers have tried the new variety and many prefer it to Ohio M-R 12. Even though the yields, as measured by baskets per acre, are not greatly different than that produced by Ohio M-R 12, it is believed that the

fruit quality of Ohio M-R 13 is superior. An increased percentage of first grade fruit means increased returns to the producer.

Previous to the introduction of the TMV-resistent varieties, susceptible varieties such as Ohio W-R 25 almost universally failed to set two or three clusters of fruit following infection with TMV. Since the new varieties are highly resistant to TMV, this failure to set fruit is eliminated to a great extent. Therefore, the production of fruit on TMV-resistant plants tends to be more nearly constant throughout the season.

The danger of mutation of TMV and the production of a new strain which will infect the new TMV-resistant varieties is always present. It is reasoned that virus mutants capable of infecting plants which possess the Tm-2^a gene are most likely to occur when susceptible varieties are grown adjacent to TMV-resistant varieties. In this case, some of the plants of the TMV-resistant varieties become infected with systemic necrosis, presumably from constant inoculation with pollinators which were first used on susceptible varieties. Even though the TMV-resistant plants are poor hosts for TMV multiplication, circumstantial evidence indicates that the virus does multiply in these hosts. Therefore, a virus mutation conceivably could take place in such plants and a strain of TMV capable of infecting the present TMV-resistant varieties could be produced.

It is probably impossible to prevent mutations of the virus. On the other hand, it appears logical that the production of such a mutation could be materially delayed if all growers of greenhouse tomatoes grew either all TMV-resistant or susceptible varieties. It would be preferable if all grew TMV-resistant varieties.

Unfortunately, it is not possible to start a breeding program for resistance to a new strain of the virus until one capable of attacking the TMV-resistant varieties is present. It is not possible to breed for resistance to something which does not exist. Hopefully, if and when a new virus strain does occur, it will be controlled by one of the other two TMV-resistant genes, Tm-1 and Tm-2. However, if a new mutant strain occurs which cannot be controlled by any of the three known TMV-resistant genes, a completely new TMV resistance program would have to be initiated.

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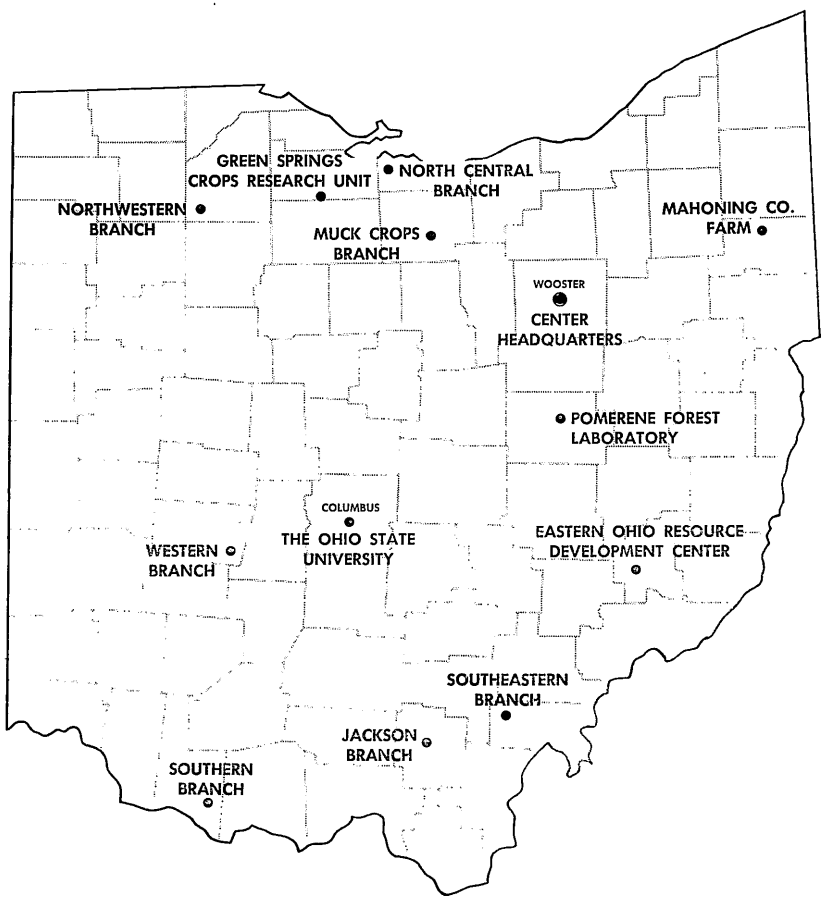

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Research is conducted by 15 departments on more than 6500 acres at Center headquarters in Wooster, nine branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, and The Ohio State University. Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 344 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Keene Township, Coshocton County: 227 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres